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GRASSHOPPER CONTROL IN THE PACIFIC STATES

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THE SEVERE grasshopper infestations of recent years have made it urgently necessary to put before the farming population in many communities the most practical and efficient methods of destroying these pests. In the Pacific Coast States conditions are such that the grasshoppers are able to develop in the immense uncultivated areas and migrate to the irrigated districts, attacking the cultivated crops and doing extensive damage.

The use of the hopperdozer, the use of fire, the destruction of the eggs in the soil, driving the wingless species and nymphs into pits, and the use of poisoned bran mixture are some of the control measures that have proved efficient under western conditions. The most successful of these has been the poisoned bran mixture, which is discussed in detail on pages 8 to 11.

The following pages also outline a program for organized community action; describe the common species of grasshoppers; and discuss control on the ranges, in alfalfa fields, in orchards, vineyards, and mountain meadows, and in corn, grain, and bean fields.

GRASSHOPPER CONTROL IN THE PACIFIC STATES [1]

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GRASSHOPPER OUTBREAKS.

The natural conditions over the Western States are such that grasshopper outbreaks may be expected for many years to come, as the immense uncultivated areas of mountains, foothills, grass lands, and alfalfa fields offer many varying conditions favorable to the abundant development of one or more of the destructive species involved. The earliest outbreaks occur on the warm, sunny, dry lands and foothills. These are followed by later outbreaks appearing on the cool, damp valley soils. The nymphs appear in greatest abundance wherever the adults have massed and deposited eggs in large numbers the preceding year. This massing of grasshoppers is normal for some species, but may be influenced by the abundance of food plants or by the presence of conditions favorable to egg laying, such as dense crowns of bunch grasses, large alfalfa crowns, uncultivated gravel soils, and dry sunny hillsides.

The destructiveness of these outbreaks depends upon many factors. The early drying of range grasses in June of 1919 was in part responsible for the abundant migration in that year of destructive species to cultivated crops. Grasshopper migration from the foothills and range lands is not so marked when there is an abundance of spring rain and grasses continue green until weeds begin to grow.

[1] The studies in regard to poisoning grasshoppers were extended to deciduous fruit orchards at the request of Dr. A. L. Quaintance, in charge of Deciduous Fruit Insect Investigations, Bureau of Entomology.

Immense swarms of grasshoppers are sometimes held on the uncultivated lands because of the presence of certain weeds which are natural food plants. Cutting meadow grasses or alfalfa on severely infested fields may cause the grasshoppers to migrate to other fields or orchards. A hot wind may cause sudden migration, while cool, dark weather frequently results in considerable inactivity on the part of these pests.

FAVORABLE AND UNFAVORABLE CONDITIONS.

Dry weather favors the development of young grasshoppers, provided they have the necessary green food, and the most severe outbreaks follow a succession of comparatively dry years. Grasshoppers usually deposit their eggs on knolls, ridges, or well-drained hillsides. In the Sacramento Valley of California grasshoppers also hatch in large numbers on grass lands which sometimes are flooded by a foot or more of water in early spring. A similar condition obtains in some of the valleys of the Sierra Nevada Mountains, where the meadows are flooded after the snows melt. Alternate freezing and thawing, or even severe drying after an early fall rain, appears to disturb many of the egg pods sufficiently to admit moisture and destroy the eggs. A heavy frost is fatal to many nymphs. Cloudy weather and cool rains are conditions unfavorable to their development.

FIG. 1.—The California devastating grasshopper.

SOME OF THE COMMON DESTRUCTIVE GRASSHOPPERS.

The California devastating grasshopper[1] (fig. 1) is yellowish brown in color, and has small dark spots on the wings. It measures about 1 inch in length. It breeds mostly on dry lands and dry alfalfa fields. The adults of this species are active in flight, and are very destructive to orchards, vineyards, alfalfa, gardens, and bean fields.

The differential grasshopper[2] (fig. 2) is a large species, measuring about 1½ inches in length. In color it varies from yellow to rich

[1] *Melanoplus devastator* Scudder. [2] *Melanoplus differentialis* Thomas.

brown, with dark markings on the legs. The wings are without distinctive markings. Some of the nymphs are almost green. It is very destructive in alfalfa fields, where it breeds in abundance, and also attacks adjoining orchards, gardens, or cornfields. This species is clumsy in flight and never migrates far.

The lesser migratory grasshopper[1] (fig. 3) is a yellowish or light brown species averaging about 1 inch in length. It breeds on waste areas and alfalfa fields, and is especially destructive to alfalfa, melons, beans, and corn.

FIG. 2.—The differential grasshopper.

The pellucid grasshopper[2] (fig. 4) is ashy brown with dark spots on the wings. A light yellowish form is sometimes present. This species breeds abundantly on grass lands, and is destructive to mountain meadows, corn, oats, beans, orchards, and gardens. It is active in flight and frequently appears in swarms.

The margined grasshopper[3] (fig. 5) is a small, dark-brown species, measuring slightly less than an inch in length, and normally is almost wingless. It breeds in alfalfa fields and foothills and attacks orchards, bean fields, and gardens.

The enigma grasshopper[4] (fig. 6) is a yellowish species about 1 inch in length. It has short wings and is awkward in flight. It breeds mostly on grass lands, and has proved very destructive to almond orchards, alfalfa, and bean fields.

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[1] *Melanoplus atlanis* Riley.
[2] *Camnula pellucida* Scudder.
[3] *Melanoplus marginatus* Scudder.
[4] *Oedaleus enigma* Scudder.

The foul grasshopper[1] is large and grayish, measuring about 1½ inches in length, with dark wing markings. It breeds abundantly on dry hillsides and attacks almond orchards along the foothills.

The red-legged grasshopper[2] is a brownish species, measuring about three-fourths of an inch in length. It breeds on waste areas and attacks alfalfa, beans, and corn. It is most abundant in the higher mountain valleys.

FIG. 3.—The lesser migratory grasshopper.

COMMUNITY ACTION.

Grasshoppers frequently develop in great abundance on the uncultivated lands, where they can do comparatively little harm, and migrate into irrigated districts, where they feed upon valuable crops on intensively cultivated areas. The ranges, foothills, grassy meadows, and uncultivated alfalfa fields are favorite breeding places from which grasshoppers frequently migrate. Such migrations are

[1] *Dissosteira spurcata* Sauss. [2] *Melanoplus femur-rubrum* DeGeer.

often so severe and sudden that communities must be organized and prepared to meet the attack in order to prevent destruction of their fields and orchards. Such work can best be accomplished by the farmers' organizations in the different localities.

The following outline is given as a helpful suggestion in organizing a community against the invasion by this pest: (1) A farmers' organization with energetic leaders; (2) the cooperation of county horticultural inspectors and farm advisers; (3) representation of the range and foothill landowners as well as those practicing intensive agriculture; (4) means of securing necessary funds for quick action; (5) a business man to locate and purchase supplies in large quantities; (6) the necessary legal advice for burning over waste areas and spreading poison on properties of nonresident and uninterested landowners; (7) reliable persons to supervise the preparation and spreading of the poison mixture; (8) definite days designated for the "grasshopper campaign," in order to cover the largest possible area at one time and thus prevent reinfestation of fields once cleaned up.

FIG. 4.—The pellucid grasshopper.

CONTROL METHODS.

The following control methods are based mostly upon the agricultural and climatic conditions prevailing over the area extending from southern Oregon through California, Nevada, and western Arizona. The methods advocated have been thoroughly tested over a period of five years and practised with excellent results on diversified farms, orchards, vineyards, and large ranches. The recurrence of serious losses to farm crops by grasshopper outbreaks can in most instances be prevented by diligent application, in due time, of the methods herein described.

There are many different methods by which grasshoppers may be fought. Some of these are: The use of the hopperdozer, destroy-

ing the eggs in the soil, the use of fire, driving the wingless species and nymphs into pits, and the use of poison in one of several attractive baits. These and other methods all have their use under certain particular conditions, and two or more of them can frequently be combined in a fight against this pest.

For general use the poisoned-bran mixture has given the most satisfactory results in grasshopper control, and this method is especially emphasized in the present discussion of the subject.

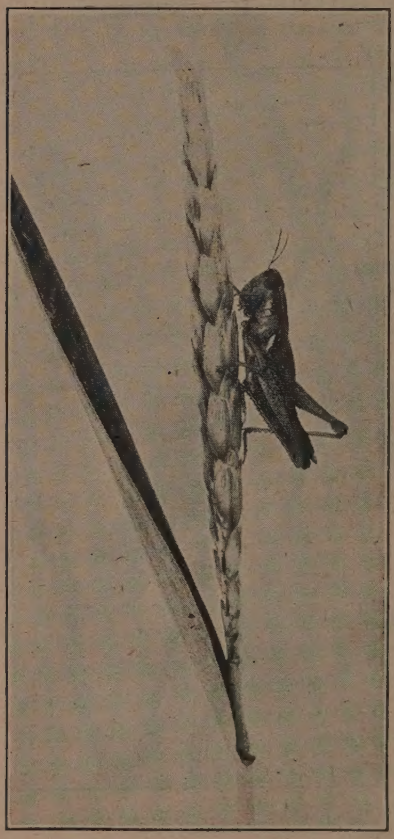

FIG. 5.—The margined grasshopper.

THE POISONED-BRAN MIXTURE.

PREPARATION OF THE MIXTURE.

The poisoned-bran mixture has given most satisfactory results in grasshopper control. When prepared it consists of a wet bran mash with sufficient poison to kill this pest, and flavored with molasses and lemon to render it most attractive. A slight variation with regard to the proportion of water required in the mixture may be necessary under varying climatic conditions. It should never be so wet that the liquid drains out. The poisoned-bran mixture apparently is most attractive while moist and fragrant with the odor of lemon and molasses, at least under California conditions, although it is taken freely by grasshoppers after drying for a day or more in the hot fields.

The following formula has proved most effective, and is recommended:

Paris green, or white arsenic		1 lb.
Molasses, cheap blackstrap		2 qts.
Lemons		½ doz.
Water	about	4 gals.
Wheat bran, or alfalfa meal		25 lbs.

This amount should be sufficient to cover about 5 acres. The cost of these materials averages from 30 cents to 50 cents per acre.

The following articles (fig. 7) are necessary, or at least convenient, for mixing the poison:

Bucket for measuring water.
Shovel, or hoe, to stir the bran.
Tub in which to mix the liquids.
Small platform or mixing box.
Meat grinder to grind lemons.
Small scales for weighing poison.

The molasses, Paris green, ground lemons, and water should be mixed in the tub and stirred thoroughly. Then slowly pour this solution over the bran in the mixing box and stir with a shovel until an even mixture is secured. It is sometimes preferable to mix the bran and Paris green dry, adding the water containing the molasses and lemon.

White arsenic may be used with good results as a substitute for Paris green, but does not mix so readily, and therefore requires much more prolonged and careful stirring to insure the best results. Alfalfa meal is a good substitute for bran, but does not spread as uniformly from a grain seeder as the coarse-flaked bran. Sour oranges and grapefruit may be used in place of the lemons.

FIG. 6.—The enigma grasshopper.

WHEN TO POISON.

The spreading of poisoned bran should begin with the abundant appearance of small grasshoppers and before actual loss to the crops has occurred. Warm sunny days should be selected if possible, since the small nymphs feed very little when it is cool and cloudy. Hot and dry weather proves most satisfactory. The grasshopper eggs usually hatch later on cool, damp soils than on dry gravel ridges, and for this reason it is sometimes necessary to repeat the spreading of poison for the complete control of this pest. If the grasshoppers

are found to spend the night under sod or clods and come out to feed in the morning, the best results are secured by spreading the poison early in the day before the grasshoppers begin moving about on the ground. On alfalfa fields, meadows, and dry-grass lands it usually is best to spread the poison in the afternoon of a hot day. Whenever the infestation is general the largest possible area should be covered in the shortest possible time to prevent reinfestation. Poisoning the grasshoppers late in the summer is of value in preventing eggs from being deposited in the soil.

SPREADING THE POISONED BRAN.

The poisoned bran mixture should be spread while it is wet, and within one day after it is prepared. It ferments rapidly in hot

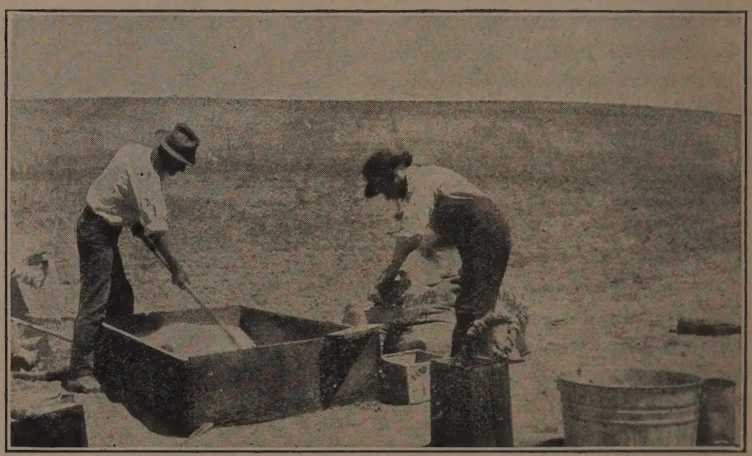

FIG. 7.—Preparing the poisoned bran mixture.

weather if allowed to stand, and there is an increased danger of poisoning live stock if sacks of the prepared poison are kept around the yard. Along fence lines, narrow ditch banks, and rocky hillsides the mixture is most conveniently spread by hand from a bucket. It should be spread as finely as possible, lumps being avoided. Over orchards, alfalfa fields, and ranges it can best be spread with an end gate grain seeder (fig. 8).[1] The poisoned bran mixture is thrown into the hopper in small quantities with a paddle or small shovel, using slightly less than a sackful of the mixture over an area of 5 or 6 acres. When properly spread it is so thin that the bran can hardly be seen on the ground.

[1] The type of seeder useful for this purpose has a horizontal spreading wheel which throws the bran mixture out with considerable force.

RESULTS TO BE EXPECTED.

Under the most favorable conditions large numbers of grasshoppers have been killed as early as eight hours after the poison was spread in the fields, but usually the maximum number of dead hoppers will be noticed two or three days later. These may be found under clods or weeds and in the crowns of alfalfa plants. The poisoned grasshoppers are eaten by other grasshoppers, beetles, and ants, in which the poison is again effective.

DANGER OF POISONING LIVE STOCK.

After the poison has been finely and properly spread over the fields at the rate of 25 pounds of dry wheat bran to 5 acres, there

FIG. 8.—The end-gate grain seeder in use for spreading grasshopper poison.

is no danger of poisoning live stock. The danger lies in preparing and keeping this attractive mixture around the farmyard where poultry and live stock are present and might eat quantities of it; also in spreading it by handfuls or lumps over the field. It is advisable to keep poultry penned up for a few days after spreading the poison; or to feed them well in the morning if they are to run at large where the poison is being spread, so that they will not pick up too many of the poisoned grasshoppers.

DESTROYING EGGS BY CULTIVATION.

Grasshoppers deposit their eggs in the soil, frequently at the bases of plants with bushy crowns. The abdomen is worked into

the soil to a depth of 1 or 2 inches (fig. 9). The eggs are deposited with a secretion which later dries and forms a waterproof protection for each egg mass. From 20 to 100 eggs may be deposited at one time. The egg pod or mass is completely sealed up before the abdomen is withdrawn from the ground.

Thoroughly cultivating and pulverizing the soil to a depth of 3 inches late in the fall will break many of these pods and expose the eggs to the action of the weather. Eggs thus exposed will mold with an abundance of moisture and will dry up if there is a lack of moisture. Alternate freezing and thawing of the exposed eggs aids greatly toward their destruction.

Spring cultivation, however, is of less value in destroying grasshopper eggs. Soil kept loose and pulverized throughout the summer is not selected by the grasshoppers as a place to deposit their eggs.

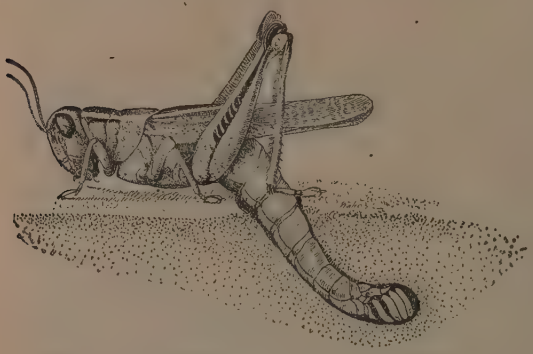

FIG. 9.—Grasshopper laying her eggs. (Webster.)

BURNING OVER DRY AREAS.

Fire has frequently been used with splendid success in connection with grasshopper control, and is practicable where the vegetation is dry and dense enough to produce a hot flame. These conditions frequently obtain in the regions to which this discussion particularly applies. The danger of fire can not be too highly emphasized, and every possible precaution should be taken to safeguard buildings, ranches, forests, and orchard trees. Burning over waste areas and fence lines during daylight frequently proves unsatisfactory because the flames drive the grasshoppers from the dry grasses into adjoining fields and orchards. Very few grasshoppers will escape the flames if the burning is done at night. Their migration from the ranges into farming communities frequently can be checked by burning over an area from 20 to 40 rods wide between the cultivated fields and the open range country.

USE OF TURKEYS.

Large flocks of turkeys are sometimes secured to feed upon and reduce the numbers of grasshoppers. Turkeys are of value in utilizing grasshoppers in such a way as to turn them into human food,

and on outlying waste areas, where no expensive crops are in danger, this is a good practice. But grasshoppers abundantly infesting alfalfa fields, orchards, vineyards, or bean fields can seldom be satisfactorily controlled by this method. The turkeys feed for a short time and then rest. Their presence also interferes with other and more effective control measures.

CONTROL ON THE RANGES.

The earliest appearance of grasshoppers is usually on the gravel soils of the rolling range lands which are warmed by the first sunny spring days. Four or five species frequently appear as very small, wingless nymphs, hopping among the grasses. One species may be especially abundant in a certain locality and a different species most abundant just a few miles away. The nymphs feed upon the grasses and develop rapidly. Winged forms usually become abundant in May and June. By this time the grasses on the unirrigated areas and foothills of California usually mature and dry. It is at this time that the grasshoppers migrate to green fields and orchards in the irrigated districts. The most pronounced migrations from the ranges follow hot winds and rapid drying of range grasses. Every effort should then be made to control these pests. The poisoned bran mixture has been most effective, and may be used with good results at reasonable cost. Migration sometimes can be checked by burning over an area from 20 to 40 rods wide between the infested grass lands and the farming community. Sometimes the grasshoppers are especially abundant on certain sunny slopes, where they can be effectively poisoned. If the area of uncultivated country is too large to cover with poisoned bran, much can be accomplished by spreading the poison in strips with grain seeders, driving about 200 feet apart, and not attempting to cover the area completely.

It is sometimes possible to drive grasshoppers back from cultivated fields, and concentrate them for more effective poisoning, by herding sheep slowly back and forth, thus keeping the grasshoppers moving in the desired direction.

CONTROL IN ALFALFA FIELDS.

Alfalfa fields become infested from two principal sources. The early infestations usually come from waste areas and range lands when the migratory grasshoppers become active. This may be followed by the abundant hatching of one or two additional species on the cool soils of irrigated fields. *Melanoplus differentialis* Thomas, a large and most destructive grasshopper, greatly favors alfalfa as food, and deposits its eggs on the ridges, ditch banks, and fence lines. *M. marginatus* Scudder, a small, short-winged form, is also a de-

structive grasshopper, especially in California, seldom migrating far from alfalfa fields, where it breeds in abundance.

The poisoned bran mixture applied early in the season along edges of the field, and later over the entire field, has given excellent results. Lightly infested fields may be cut so as to leave strips, or lands, of standing alfalfa to attract and concentrate the grasshoppers. They can then be poisoned at a comparatively small cost. The grasshoppers usually roost on the alfalfa stems during warm nights, feed early, and descend to the ground as the heat of the sun becomes intense. They feed ravenously in the late afternoon following a hot day. The best results therefore are secured by spreading the poisoned bran mixture on fields with standing alfalfa in the afternoon of hot, dry days.

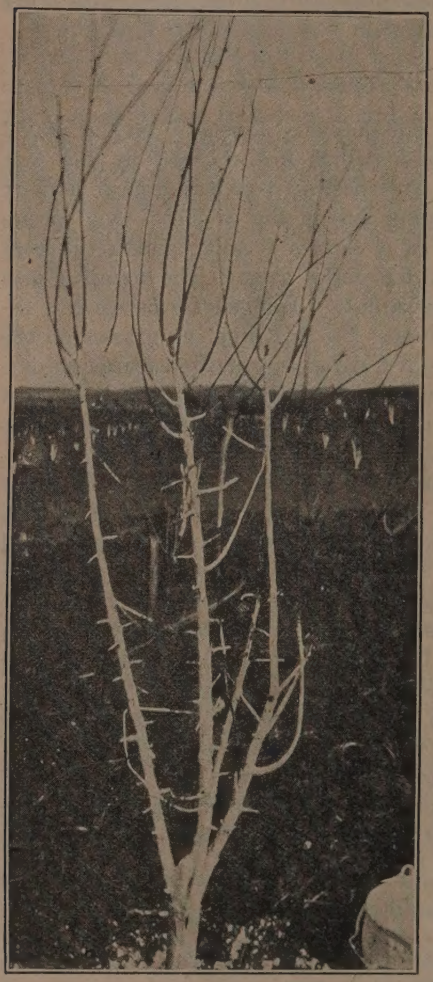

FIG. 10.—Grasshopper injury to fruit tree.

CONTROL IN ORCHARDS AND VINEYARDS.

Orchards (fig. 10) and vineyards suffering most severely from grasshopper attacks are those bordering on or within the radius of grasshopper migration from infested alfalfa fields, foothills, or waste areas. Grasshoppers do not deposit their eggs in the loose soil of carefully cultivated orchards. Uncultivated fence lines or roadsides may, however, be a source of infestation. Every effort should be made to poison the grasshoppers before they enter the trees or vines. If they are already present in the orchard, the poison should be spread over the ground and the grasshoppers shaken from the branches and kept moving so

that they will find the poison. On the cultivated soils the grasshoppers frequently descend in the evening and spend the night under the warm clods. Best results are then secured by spreading the poison in the morning, since the grasshoppers again make their appearance with the first rays of the morning sun and will take the poison bran before entering the trees. The poison mixture never should be placed in small piles against the trees, since burning of the bark may result. Covering small trees with cheesecloth or burlap frequently is practised, but is useful only for temporary protection (fig. 11). Grasshoppers eat through the lighter material and girdle the tree where the cloth is tied, unless it is extended to the ground.

FIG. 11.—Part of an almond orchard. Small trees covered with cloth. The grasshoppers soon ate through the cloth and girdled many trees where the cloth was tied.

CONTROL IN MOUNTAIN MEADOWS.

Mountain meadows frequently become infested from the grassy slopes of surrounding hills and from low ridges, where the grasshoppers collect in the fall to deposit their eggs. The small grasshoppers appear in early summer and destroy the valuable meadow grasses. The poisoned bran mixture has given splendid results in destroying grasshoppers under these conditions, and in some sections has saved stockmen thousands of dollars' worth of fodder. The poisoning should begin when the nymphs appear in considerable numbers, and should be continued until late in the fall, even after the crops have been removed from the fields, if necessary. This later poisoning is to prevent the laying of eggs in the soil.

CONTROL IN CULTIVATED FIELDS.

Corn, grain, and bean fields frequently suffer severe injuries from grasshopper attacks. Such infestations usually come from uncultivated, waste areas and alfalfa fields, to which the grasshoppers frequently return for the night. The poisoned bran mixture should be spread over such adjoining waste areas, as well as on the fields where the crops are injured. On the cultivated fields it is well to spread the poison during the morning hours, when the grasshoppers are coming in.